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A Summary of Current Program and
Preliminary Report of Progress

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RESEARCH ON

NAVAL STORES and MAPLE SAP AND SIRUP PROCESSING AND PRODUCTS

REVEGETATION and WEED AND BRUSH CONTROL ON FOREST AND RELATED RANGES

SHADE-, ORNAMENTAL-, and WINDBREAK-TREE BREEDING, DISEASES AND CULTURE

of the Agricultural Research Service,
United States Department of Agriculture
and cooperating
State Agricultural Experiment Stations

This progress report of USDA and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having an interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly USDA publication Agricultural Research.

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UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D.C.
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Copies of this report may be obtained from David J. Ward, Executive Secretary, Forestry Research Advisory Committee, U.S. Department of Agriculture, Washington, D.C. 20250

INTRODUCTION

This is ONE part of a TWO part report of cooperative USDA research relating to all aspects of forested land and related ranges.

This part of the Forestry report deals with research conducted by certain divisions in the Agricultural Research Service; the other and larger part includes discussions of all Forest Service research. Limited information about work in cooperation with State Agricultural Experiment Stations is included in discussions of research progress.

Agricultural Research Service (ARS) investigations with naval stores and maple sap and sirup deal with the development of new and improved products and processing technology and the acquisition of basic knowledge about chemical composition and chemical and physical properties of these products. During the past fiscal year, about 12.0 scientist man-years were devoted to naval stores utilization research and 4.0 to maple investigations.

The portion of ARS range improvement research covered in this report deals with problems associated with revegetation and fertilization of forest ranges. Methods of seeding, establishing, and managing ranges for domestic livestock are studied together with evaluations of the suitability of grass species or varieties for use as range plants. ARS investigations in this area involved about 15.0 scientist man-years in fiscal year 1967.

Research on the control of weeds and brush on forest and related grazing lands is a part of ARS weed control studies with forage and range plants. In fiscal year 1967 about 11.0 scientist man-years were devoted to the area of work covered in this report.

ARS studies with trees for shade, ornamental and windbreak purposes involve 9.2 scientist man-years.

The above estimates of scientific effort do not include parts of some programs of a basic research that will produce results of value to many problem areas.

Successful applications of results of agricultural research have been numerous and impressive. A few examples from the research areas covered in this part of the report are presented here.

> New Chemical Products from Pine Gum Now Undergoing Industrial Evaluation. Three new chemical products with good industrial potential have recently been prepared from crude pine gum. The first is a member of a new class of heat-resistant plastics. A leading manufacturer of these polymers is testing this compound as a modifier for a commercial product. Two other compounds, evaluated in the current program of screening naval stores products as industrial

chemicals, have proved to be exceptionally active as nematocides -- agents for which there is a large and growing market. Both new nematocides have attracted the attention of at least two large manufacturers of agricultural chemicals, one of which is currently evaluating one of the compounds in its own laboratories.

Continuous Process for Intensifying Maple Sirup Flavor. A continuous high-flavoring process developed by ARS scientists has been received with enthusiasm by the two principal packers who use more than 70 percent of the available bulk maple sirup in their cane-maple blended products. The process is based on a high-temperature short-time treatment in which the liquid sirup is pumped through heat exchangers under high pressure. At temperatures 70° to 100°F. above that used in making maple sirup, flavor precursors interact rapidly and more completely to yield a 2- to 40-fold increase in flavor. The operator can also control the color and flavor intensification for specific applications.

With this process, 80 to 90 percent of the U.S. commercial sirup production can be made to meet the blenders' color and flavor specifications. In poor crop years, such as 1967, these high-flavored sirups help extend the crop to supply sufficient sap for the blending segment of the industry.

Moistening Seed Treatment Hastens Seedling Emergence. Wetting (but not submerging) seeds of crested wheatgrass with tap water for about 60 hours at 63F. and then drying them enabled these seeds to germinate and emerge from 1/2 inch planting depth in about 40 hours less time than untreated seeds. The advantage persisted when treated seeds were planted as much as six months after the treatment in greenhouse studies conducted at Logan, Utah. During the first three days after emergence began, roots from treated seeds were 20 mm longer than those from untreated controls.

Poisonous Principle Isolated. The poisonous principle in timber milkvetch has been isolated in pure form after separation in a counter-current distributor in Utah. Identification studies are continuing.

Improved Technique for Rooting Dutch Elm Resistant Elms. Disinfection of stem cuttings of species of elms improved the percentage of rooting. Tests showed that Fusarium solani caused stem and root rot of the cuttings and that its damage could be reduced by flaming the cuttings. Only 28 percent of untreated cuttings rooted, while 56 percent of the flamed cuttings rooted. A few rooted cuttings have been obtained from the tetraploid Ulmus pumila produced in 1966.

NAVAL STORES UTILIZATION - INDUSTRIAL PRODUCTS
Southern Utilization Research and Development Division

Problem. More uses for pine gum, rosin and turpentine need to be developed through research to provide industrial markets for current and anticipated production of gum naval stores. The recent decline in use of gum rosin has resulted in the accumulation of a considerable surplus of this commodity. Other types of rosin as well as synthetic chemicals backed by strong industrial research programs have made serious inroads on the traditional markets for gum rosin. Gum turpentine is also faced with similar competition. If the turpentine farmers of the Southeast are to continue to find profitable markets for their pine gum, existing knowledge of the properties of this commodity and its derived products must be used to develop new uses and strengthen old ones. New fundamental information about the chemistry of the terpenes and resin acids is also needed to fully exploit their unique characteristics. New or expanded uses for naval stores products are especially needed in polymers, plastics, elastomers, resins, plasticizers, surface coatings, textile finishes, odorants, insecticides, herbicides, and other large-volume industrial chemicals. There is also a serious need to improve existing processes and develop new processing technology for the industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program at Olustee, Florida, involving organic chemists and a chemical engineer engaged in both basic and applied research to discover and develop new and improved uses for pine gum and its products. In basic research on the chemical composition, physical properties, and structure of gum naval stores materials, emphasis is on the isolation and characterization of some of the unidentified components in pine oleoresin and gum rosin that contribute to the superiority of gum rosin over other rosins as an industrial material. In the area of process and product development, the research is directed toward the development of new and improved industrial products from pine gum, rosin, turpentine and their components, and suitable processes for producing these industrial products. Research is being conducted to develop economical processes for the preparation of polyglycols and polyethers from rosin, resin acids and pine gum for use in polyurethane elastomers and foams; to investigate the chemistry of the photoperoxides of pine gum to develop useful intermediates for the chemical industry; to explore various high-temperature reactions of gum rosin, rosin derivatives, resin acids and resin acid derivatives to develop new and unusual products having potential industrial utility; and to find practical methods for increasing the utility of terpenes and resin acids from pine gum by free radical addition of acids, aldehydes and other compounds to the olefinic bonds of these materials, thus increasing their functionality. Informal cooperation is maintained with other agencies, industrial firms, and universities in connection with the naval stores research program. The U.S. Forest Service cooperates by supplying selected samples of pine gum.

Additional research on process and product development is in progress under contract at the University of Florida, Gainesville, Florida, on the development of a practical process for the conversion of α-pinene to dimers in good yields, and the conversion of these dimers to useful, reactive derivatives; and at Battelle Memorial Institute, Columbus, Ohio, on investigations to expand the use of gum rosin and its derivatives in the adhesives industry.

Research in the field of chemical composition, physical properties and structure is in progress under a grant of P.L. 480 funds to the Juan de la Cierva School of Technical Investigations, Barcelona, Spain, for development of new or improved methods of preparing selected terpene alcohols for use as standards, to obtain basic information on the composition and properties of products made from pine gum (project duration - 3 yrs.).

The Federal in-house scientific research effort in this area totals 12.0 scientific man-years. Of this total, 0.2 is devoted to chemical composition, physical properties and structure and 11.8 to technology--process and product development. The contract research involves an additional 1.7 scientific man-years on process and product development. P.L. 480 research involves one grant for research in the field of chemical composition, physical properties and structure.

The following lines of work were terminated during the year: (1) the preparation of polymerizable monomers for vinyl and condensation-type polymers from terpene acids and terpene acid derivatives, and (2) synthesis of terpene alcohols and glycols by reaction of formaldehyde with terpenes derived from gum turpentine, and study of use of these products in making polymers (both under Technology--Process and Product Development).

PROGRAM OF STATE EXPERIMENT STATIONS

One scientific man-year is devoted to this area of research.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition, Physical Properties and Structure

1. Composition and Physical Properties of Pine Gum. Research to identify some of the unidentified components in pine oleoresin and rosin was recently initiated. Several samples of the neutral portions of oleoresin and rosin have been isolated and examined by gas chromatography. Preliminary indications are that these fractions are complex mixtures containing as many as 40 to 50 components. One of the major components has been isolated and tentatively identified as 3,5-dimethoxystilbene. (S5 2-60).

Under a P.L. 480 project now nearing completion at the Patronato "Juan de la Cierva" School of Technical Investigations, Barcelona, Spain, research has been conducted to develop new or improved methods for synthesizing,

isolating and purifying selected terpene alcohols for use as standards in instrumental methods for determining the composition and properties of products made from pine gum. Recent progress has resulted in the preparation of seven previously unreported terpene 7- and 9-alcohols, in addition to some 30 such compounds reported earlier. These compounds, together with a number of purified intermediates, have been supplied to the Naval Stores Laboratory at Olustee, Florida, together with details of their synthesis, purification, analytical characteristics and spectral properties. These pure terpene alcohols of known structure will serve as standards, and provide much useful information for the instrumental analysis and characterization of naval stores products required in their processing into industrially useful materials. (UR-E25-(50)-36).

B. Technology--Process and Product Development

1. Development of Intermediates for the Production of Resins, Plastics, Plasticizers, and Other Industrial Products from Pine Gum and Its Components. Research to produce useful chemicals from terpenes and resin acids by free radical addition of functional groups has continued. To provide a basis for selecting solvents and catalysts for free radical additions to resin acids, the stability at room temperature of levopimaric acid dissolved in various solvents, with and without added peroxides, has been investigated. No change in levopimaric acid was found when its cyclohexane solutions were stored for about six weeks; little change was observed for acetone solutions; but extensive isomerization occurred in carbon tetrachloride or methanol solutions. Isomerization in freshly distilled bromotrichloromethane was even faster than in carbon tetrachloride. Addition of benzoyl peroxide catalyst resulted in almost complete dehydrogenation of levopimaric acid in all solvents; di-t-butyl peroxide gave very little dehydrogenation, especially in cyclohexane and in acetone. Progress has been made in isolating and characterizing the products from the di-t-butyl peroxide catalyzed reaction of each of the following compounds with diethyl phosphite: limonene, carvomenthene, camphene, α- and β-pinenes, myrcene, abietic acid and levopimaric acid. Derivatives of this type may prove useful as stabilizers and plasticizers, fire retardants, and oxidation inhibitors. A copper-alkali system recently discovered in other research may provide a lower cost alternate to peroxides as the catalyst for addition of carbon tetrachloride to terpenes. (S5 2-57).

Good progress has been made in the research to convert rosin, resin acids, and pine gum derivatives into polyols for use in polyurethane applications. Hydrogenation has proved particularly useful for stabilizing formaldehyde-modified rosin from loss of formaldehyde and should enable the facile preparation of useful polyols from rosin. Hydrogenation and subsequent saponification of the acetate resulting from the reaction of abietic acid and paraformaldehyde gave a stable mixture containing about 60% of dimethylolated and 35% of monomethylolated products and 5% of unreacted acid. Reduction of the carboxyl function produced a mixture of a di- and triol. The reaction of propylene oxide with various hydroxymethylated

rosins and with the acrylic, maleic and fumaric adducts of levopimaric acid and of rosin has resulted in a large number of hydroxylated materials, some of which should have value as adhesives, polymers, and polymer modifiers. Vinyl esters of various hydrogenated rosins are being studied to determine which rosins will be most useful in the polymer field. (S5 2-56).

In contract research (University of Florida) optimum conditions were determined for dimerization of α-pinene with phosphoric acid catalysts. It was demonstrated that this dimer has a highly hindered tricyclic structure with one tetra- and one trisubstituted double bond. The diepoxide prepared from the dimer has an unusual structure and may have potential in polymer applications. A second dimer from the phosphoric acid catalyzed dimerization is being identified. The structures of the dimers prepared with boron trifluoride-phenyl dichlorophosphine as the catalyst were also established. Indications are that these dimers should be more reactive and possibly more useful as chemical intermediates. They may have utility as ultraviolet screens or stabilizers. Titanium tetrachloride-nitromethane gave good yields of dimer and the product had only two major components. The cost of catalyst in this system is also favorable. Zinc chloride-nitromethane was found to be a particularly attractive and effective catalyst for the dimerization of α-pinene. This catalyst is cheaper and more convenient to use than titanium chloride-nitromethane, and it produces a simpler dimer mixture with less isomerization. Products obtained by dehydrogenating and oxidizing the dimers are being characterized. (S5 2-49(C)).

2. Conversion of Rosin Acids, Pine Gum and Turpentine into New Polymers, Protective Coatings, Resins and Plastics. In recently initiated research, high-temperature rearrangements or pyrolysis of gum rosin, resin acids, and their derivatives are being investigated as a basis for producing new materials of potential industrial utility. Of several approaches investigated for high-temperature rearrangements of rosin and resin acids, the passage of these materials through a hot tube at 1000°C offers the most promise and is currently receiving further study. It has been found that on heating abietic acid, gum rosin, wood rosin, or tall oil rosin above 180°C, an equilibrium mixture of abietic, palustric and neoabietic acids is rapidly formed. Because of the formation of this equilibrium mixture, the pyrolysis at 1000°C of any one of the four pure conjugated dienic resin acids may give the same results. (S5 2-58).

In continued research on epoxides and ozonoization products of resin acids and their derivatives, a large number of compounds were prepared for testing as agricultural chemicals at the University of Florida. Hydrogenation of maleopimaric acid has been explored as a means of producing improved heat-resistant polyimide-amides from this acid. A large manufacturer of heat-resistant plastics is strongly interested in the use of polyimide-amides from maleopimaric acid as a modifier for one of their existing commercial products. (S5 2-52).

Mono-esters prepared by condensation of ethylene oxide or propylene oxide with rosin have been found to have a high abietyl content and to react readily with dienophiles. Because of their high reactivity and lower cost than esters prepared by direct esterification of rosin and glycols, these mono-esters should be attractive intermediates for preparing high molecular weight polyester resins. A promising new type of polyester has been obtained by reacting rosin with permaleic acid to produce rosin epoxides followed by further esterification of the maleic acid formed. A ready source of pimaric acid has been provided by the discovery of a new method for isolating this acid, as its 2-aminoethanol salt, from pine gum. (S5 2-53).

Research investigations to expand the use of gum rosin and its derivatives in the adhesives industry are being initiated under contract at Battelle Memorial Institute. Initially, four selected rosin-based products, including ethylene-gum rosin copolymer and hydrogenated rosin-ethylene copolymer, will be evaluated as components of four specific types of adhesive classes. Other products to be tested are being prepared. (S5 2-59(C)).

A rapid, convenient process for the preparation of levopimaric acid transannular peroxide has been developed. It utilizes singlet oxygen generated by the reaction of hydrogen peroxide and sodium hypochlorite. Unfortunately, use of the technique on pine gum and gum rosin gives products which contain low amounts of peroxide in comparison with that achieved by photosensitized oxidation. Several additional reactions of levopimaric acid transannular peroxide, including those with cyclohexylamine, α-pinene, mineral acids and carboxylic acids, have been explored. (S5 2-61).

In contract research at Cornell University, good yields of primary alcohols have been obtained by reacting formaldehyde with camphene, limonene, and α-terpinene. The processes for making these terpene alcohols are simple and practical, and the products are attractive chemical intermediates. It has been demonstrated that they can be converted to high-boiling diesters and polymerizable methacrylates. (S5 2-46(C)).

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MAPLE SAP AND SIRUP UTILIZATION - FOOD
Eastern Utilization Research and Development Division

Problem. The extensive unused stands of sugar maple trees are largely located in agriculturally depressed areas that are commonly devoted to small-scale dairy farming. Since only a small percent of the available sugar maple trees are presently tapped for sap production, and about 50% of the sirup consumed in the United States is imported, untapped sugar maples represent a good potential source of increased cash income for farmers in these areas. The maple area includes 14 States from Minnesota to Maine and south to Virginia. Under proper conditions, maple sirup can be a six-weeks seasonal crop not in competition with other farm activities and with a per acre value equal to or exceeding that of other farm products. Based largely on recent research carried out in the Department and the State Experiment Stations, the methods of collecting and processing sap into sirup are being streamlined. This has resulted in greatly increased efficiency and larger hourly returns to the sirup producer for his labor. The advent of tube collection and transportation of sap has reduced the cost of sap handling 40% and has eliminated much hand labor.

Oil-firing of evaporators and improved systems of steam removal have provided efficient and sanitary plants. The taphole germicidal pellets and sanitary methods of sap handling have tended to stabilize crop yields and standardize sirup quality. While the results of previous research have contributed to modernization of the industry, much more information is needed so that all operations for the production of high-quality maple sirup and other maple products can be conducted in a predictable, efficient manner. Not only can the low income farms be greatly benefited, but the existing maple industry can be put on a higher economic plane and modernized to be made competitive with other crop and livestock farming to bring about improved land use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program involving chemists, biochemists and microbiologists. These scientists are engaged in both basic and applied research in investigations concerned with the problems of improving sap handling and processing, producing high-quality maple sirup, and developing new outlets for all maple products while lowering the cost of the product. Most of this work is conducted at Wyndmoor, Pennsylvania.

The Federal scientific effort devoted to research in this area totals 4.0 scientist man-years. Of this number, research on chemical composition and physical properties comprises 1.0, research on microbiology and toxicology comprises 1.0, and research on technology--process and product development comprises 2.0, including 0.1 in contract research on sap storage with J. L. Sipple & Son, Bainbridge, New York. In the research work, cooperation is maintained with personnel of the Federal Extension Service in maple-producing States and with Cornell University.

PROGRAM OF STATE EXPERIMENT STATIONS

A total of 1.5 scientist man-years is devoted to this area of research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

Methyl ethyl ketone can extract flavor precursors from maple sirup that has been extracted with chloroform, which removed maple flavor. The concentrated methyl ethyl ketone extract has a sweet, slightly maple-like odor. However, an attempted GLC separation revealed no compounds contributing to the flavor. This suggests that (a) the material in the extract is very low in volatility or (b) is in such small amounts as to escape detection. When the flavor-containing chloroform extract of maple sirup is subjected to a GLC-mass spectrograph tandem procedure the more volatile part of the extract was found to have small amounts of many compounds. Further work must be done to determine whether these are artifacts, contaminants or real constituents of maple flavor.

B. Microbiology and Toxicology

Ultraviolet irradiation is an effective method for controlling microbial growth in maple sap. A test microbial population of 2×10^6 organisms per ml., was reduced to 0.9% of this count by ultraviolet radiation and a recirculation rate sufficient to effect complete recirculation of the sap in a 60-gallon test vessel in two hours. Hypochlorite sanitizers providing 50 parts per million of chlorine were found to be effective in sanitizing reverse osmosis apparatus. Fifteen minutes exposure reduced microbial counts over 10^6 organisms per ml. to less than 10 organisms per ml. However, the high pH of the hypochlorite sanitizers have a deleterious effect on the reverse osmosis membranes. This effect can be minimized by washing the membrances with acetate buffer at pH 4.5.

C. Technology - Process and Product Development

1. Maple sap storage. Maple sap irradiated by inline ultraviolet lamps as it was run into storage, followed by continuous irradiation of the surface of the stored sap showed no deterioration after one week of storage. The grade of the sirup produced was identical with sirup made from fresh sap. Sap treated by surface irradiation only had a higher microbial count and produced sirup at least one grade darker than fresh sap. The control sample, sap stored without exposure to ultraviolet radiation, had a high yeast and bacterial count at the end of one week and the sirup produced was at least two grades darker than sirup made from fresh sap.

2. Reverse osmosis. A four-module reverse osmosis unit was tested on fresh sap of the 1966 season. The data confirmed exploratory experiments. Sap was successfully concentrated from its original Brix of 2.5° to 10°, that is, 75%

of the water was removed by reverse osmosis. The 10° Brix concentrate when concentrated to 65.5° Brix sirup by conventional boiling had full-bodied maple flavor with no detectable foreign flavor. The loss of sap solids in the byproduct water was approximately one part in 2000.

A pilot plant reverse osmosis unit under construction is designed to handle up to 10,000 gallons of maple sap per 24-hour day to produce a 10° - 12° Brix sap for finishing by conventional atmospheric boiling. The concentration of maple sap by thermal distillation is one of the more costly of the different steps involved in maple production. The use of reverse osmosis to remove most of the water would be a much less expensive method.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

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Microbiology and Toxicology

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Technology -- Process and Product Development

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RANGE SEEDING AND ESTABLISHMENT OF FOREST AND RELATED RANGES
Crops Research Division

Problem. In the western United States about two-thirds of the land is used for grazing. With increased demands for livestock products rangelands must be made more productive. Research must provide not only better forage plants but efficient procedures by which they can be established on rangeland, and the knowledge essential to their proper management and efficient utilization. On many millions of acres brush must be destroyed and desirable forage plants established. Forage plants having superior nutritional qualities, as well as adaptation to arid sites, need to be developed. In order to accomplish these important goals rangeland research needs to be substantially intensified.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving agronomists, plant physiologists and range scientists engaged in basic and applied research on the management and improvement of grazing lands.

There is one P.L. 480 project in Israel concerning establishment and maintenance of seeded dryland range under semiarid conditions.

The Federal scientific effort devoted to research in this area totals 15 scientific man years. Of this number 5.8 are devoted to seeding and establishment, 3.1 to quality and variety evaluation, and 6.1 to physiology and biochemistry.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Quality and Variety Evaluation

1. Russian wildrye retains relatively high digestibility. Russian wildrye has high digestibility early in the growing season and digestibility remains relatively high considering the universal decline in herbage digestibility as it matures. Studies at Mandan, N.D., revealed a digestibility of 71.78% on June 15, 61.52% on June 24, 53.01% on August 2, and 45.91% by October 5 from samples collected in a pasture being grazed yearlong. The feed-feces technique of Van Soest was used. Crested wheatgrass began with comparable values, but declined faster as the season advanced.

2. Species altered by N on abandoned cropland. October application of 40 lbs. N/acre for three consecutive years on abandoned cropland at the Central Plains Experimental Range reduced perennial grasses 43% (principally 3-awn reduced 50%, and sand dropseed reduced 8%), a desirable trend, but increased lambsquarter 14-fold, an undesirable trend, while perennial

forbs and other annuals were unaltered. Total herbage production was doubled each year. Heavier rates of N only tended to increase lambsquarter and decrease perennial grasses without changing total yield.

3. Weed control and N fertilizer renovate old crested wheatgrass. A 30-year old crested wheatgrass pasture at Mandan, N.D., was restored to high productivity by control of fringed sage with 2,4-D and applications of 40 lbs. N/acre/year. After highest production the first year of grazing the pasture declined from 133 lbs. beef/acre to an average of 70 lbs. the last seven years of the 30-year period. The control of sage and fertilization for four years then resulted in a four-year average productivity of 159 lbs. beef/acre. The highest monetary return over the cost of treatment was for spray only, but a combination of spray and N produced 70% more forage.

B. Physiology and Biochemistry

1. Cheatgrass, a heavy seed producer, seldom germinates completely first year. The popular idea that in a favorable year essentially all cheatgrass seed germinates is false according to work conducted at Logan, Utah. The fall of 1965 was warm with abundant moisture. By late fall about 475 seedlings had emerged per sq. ft. of cheatgrass sod, but an additional 400 to 700 seedlings emerged when the sod was removed to a greenhouse and watered. Sods checked in the late spring of 1966 contained from 600 to 1000 seedlings per sq. ft., but these sods, under favorable greenhouse conditions yielded an additional 150 to 400 seedlings per sq. ft. The data also point out the numerical advantage and hence the competitive effect cheatgrass has on crested wheatgrass seedlings where 5 lbs./acre represents about 20 seeds/sq. ft.

2. Leaf analysis a guide to fertilizer needs of forage plants. Nitrate nitrogen concentrations in selected leaf tissue of tall and intermediate wheatgrass and Idaho fescue revealed the critical level to be approximately 500 ppm in studies at Berkeley, Calif. When tissue contains more than 500 ppm the nitrate needs of these species are adequately met, while below 500 ppm the plants will respond to applications of N. The nitrate, phosphate, and sulfate critical concentrations in young leaf tissue of Italian ryegrass were found to be 1000, 750, and 100 ppm, respectively.

3. Phosphorylation occurs in seeds at low water potential. At Pullman, Washington, seeds of crested wheatgrass were able to synthesize unidentified phosphate esters when their water potentials were reduced to -880 atmospheres during a five-day period of absorption under controlled relative humidity. When the water potential was reduced to -130 atmospheres the seeds synthesized adenosine triphosphate, uridine, diphosphate hexose, nicotinamide adenine dinucleotide, and some other unidentified phosphate esters. As the water potential was further lowered additional activities and greater concentrations of phosphorylation products occurred. The water potentials studies ranged from -2600 to -40 atmospheres, representing seed moisture contents of 6 to 30%, respectively.

C. Seeding and Establishment

1. Species survive in arid Panoche Hills. A few species represented by annual legumes, a perennial grass, and shrubs may be suitable for seeding in the dry Panoche Hills area along the inner coastal range in central California. Kondinin rose clover, California bur clover, Harbinger medic and Medicago littoralis, and the Yamina variety of cup clover were successful annual legumes. Pubescent wheatgrass A-1488, Atriplex polycarpa and Isomeris arborea were successful perennials. The perennials survived a 10-month period receiving only 1/2 inch of rain in 1966. The annuals reproduced themselves to bridge the dry period. All species were seeded in 1965.

2. Moistening seed treatment hastens seedling emergence. Wetting (but not submerging) seeds of crested wheatgrass with tap water for about 60 hours at 63°F. and then drying them enabled these seeds to germinate and emerge from 1/2 inch planting depth in about 40 hours less time than untreated seeds. The advantage persisted when treated seeds were planted as much as six months after the treatment in greenhouse studies conducted at Logan, Utah. During the first three days after emergence began, roots from treated seeds were 20 mm longer than those from untreated controls.

3. Fungicides control Podosporiella without lowering seed germination. At Logan, Utah, Captan at 8 oz./100 lbs. seed and Thiram or Semesan at 6 oz./100 lbs. seed gave excellent control of Podosporiella verticillata if germination and seedling emergence occur soon after planting in either greenhouse or field tests. When germination is delayed several weeks or months, fungus control is fair to good. Captan and Thiram can be applied at rates of 12 and 8 oz./100 lbs. seed, respectively, without lowering seed germination. Semesan was not tested at rates above 6 oz./100 lbs.

4. Summer seeding on plowed land best for 4-wing saltbush. At Flagstaff, Arizona, good stands of 4-wing saltbush have been consistently obtained only from summer seeding on plowed land, with seeds planted in shallow furrows. If seeding is done in conjunction with undercutting, the undercutting must be thorough. Dalapon spray was too slow for seedbed preparation involving destruction of blue grama sod.

5. Atrazine fallow increases soil nitrogen: delays seeding. Chemical fallow using atrazine at 1 lb./acre to aid establishment of perennial grasses was effective in cheatgrass control and also permitted a four to nine fold increase in nitrate-N, in studies conducted at Reno, Nevada. Where control plots contained 6 lbs. N/acre those chemically fallowed 18 months had from 23 to 58 lbs. N/acre in the 0-6" depth. With only .03 to .06 ppm atrazine remaining in the soil, mortality of Amur intermediate wheatgrass seedlings was as high as 14% while .15 ppm atrazine permitted no seedlings to survive. In field practice 1 lb./acre atrazine applied in the fall left .31 to .53 ppm in the top inch of soil the following spring.

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WEED AND BRUSH CONTROL ON FOREST AND RELATED RANGELANDS
Crops Research Division

Problem. Approximately half of the total land area of the United States is used for pasture and grazing purposes and weeds and brush are a problem on nearly all of these forage lands. Economic losses from weeds on grazing lands are virtually incalculable and include poorer livestock products, delayed livestock gains, and livestock poisoning. Unfortunately, efforts directed at correcting weed and brush problems of grazing lands have been minimal. Almost every year there is an increase in the scope of the problem. Increases in the problem are evidenced by information from New Mexico: in 1858, mesquite dominated only 5% of the land, in 1963 50%; in the same time creosotebush increased from 1% to 14% and tarbush from 1% to 9%, respectively. Expansion of fundamental studies on the physiological and biochemical responses of weeds as affected by environment, soil, plant structure, and time and method of application is essential to increased effectiveness of herbicides. Research on the integration of herbicide and herbicide-cultural methods of weed control into management systems should be expanded.

USDA AND COOPERATIVE PROGRAM

The U.S. Department of Agriculture has a continuing long-term program in both basic studies and the application of known principles to the solution of weed problems. Although research is being conducted which has general application in all areas of weed control, such studies on herbicide evaluation, on the mode of action of herbicides, on fundamental principles of the role of surfactants in herbicidal effectiveness, and on the behavior and detoxification of herbicides in soils, only the research directly related to control of weeds and brush on grazing lands is included in this report. The latter includes studies of the life histories and growth patterns of individual weeds, principles of competition among weeds and forage plants and the use of cultural methods, biological agents and herbicides for their control. Comprehensive studies are made to develop principles, practices and methods of using herbicides and other weed control techniques in solving regional and national weed and brush problems in grazing lands.

Research on the control of brush and weeds on grazing lands is conducted cooperatively with State Agricultural Experiment Stations and with Federal agencies, including the Bureau of Reclamation and Bureau of Land Management, Department of the Interior, and the Forest Service of the Department of Agriculture. Industrial companies cooperate in furnishing experiemental chemicals, equipment, and funds essential to rapid progress in weed control investigations.

The Federal scientific effort devoted to weed and brush control research on

rangelands in or near forested areas is 9 scientist man-years and 2.0 scientist man-years on the control of phreatophytes.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Weed Investigations - Grazing Lands

1. Poisonous and Other Herbaceous Weeds

a. Physiological and Ecological Studies

Weed Competition. The main effects of weed competition in microenvironment within establishing alfalfa are directly related to the height and composition of the canopy developed. In Indiana, this is noted in the measurement of outgoing radiation, air temperatures in and above the crop, soil temperature, vapor pressure, and saturation deficits. Generally, the more open the canopy the closer the parameters become. The more complete the ground cover, the more outgoing radiation recorded and the lower the air temperature within the stand and soil temperature.

A pigweed leaf-area index of one reduces the entire visible spectrum penetration by over 95%. Pigweed competition in the seedling year is greater than giant foxtail as measured by alfalfa stand reduction, yield, crown diameter and rate of recovery after weed removal.

The Hy-Cal 180° pyrheliometer,Model P-8405, is equal to or better than the standard Eppley 50 junction pyrheliometer for the measurement of solar radiation. It has advantages in weight, size, accuracy, stability, response time, and ruggedness.

Plot size can affect some of the microenvironmental parameters in and above a stand of alfalfa. In plots 50' x 50' or larger, there was no difference in outgoing solar radiation. There was little difference in air temperature above alfalfa stands in plots 50' x 50' or 100' x 100', but the smaller plot had a higher temperature in the morning and a cooler temperature in the evening within the alfalfa stand. Soil temperatures in 25' x 25' plot size were higher than all other plot sizes studied. Humidity measurements have the greatest variability with the smaller plots having the greatest saturation deficits in the crop. Larger plots may have as much as 100 ppm higher CO_2 level in the crop at night. Almost all the variation due to plot size can be explained on the basis of border effect at any stage of stand development.

Thistle Complex in Nebraska. The seed germination responses to combinations of low temperatures and moisture were highly variable among 8 species of thistles in 1965 and 1966. Cirsium discolor, C. vulgare, and C. flodmani usually did not respond significantly to cold treatments. Cirsium undulatum and Carduus nutans germinated better when given cold treatments. Scarification, acid treatment, and soaking in gibberellic and

indole acetic acid failed to stimulate germination in Cirsium discolor. There was great variation in germination of Carduus nutans among samples collected at many locations in Nebraska.

More musk thistle seedlings became established in nongrazed, cool season grass pastures than in nongrazed, mixed warm season grass pastures. The cool season species, bromegrass and intermediate wheatgrass, grow in more open stands than the warm season grasses or weed infested Kentucky bluegrass pasture. Most of the musk thistle plants that germinated in the protected areas in 1965 had succumbed to the heavy competition by 1966.

Musk thistle seed collected at various locations across the State of Nebraska were planted August 11, 1965, and the resulting plants flowered in June 1966. Some gross morphological variations were seen among the plants from different localities. Selfed and open pollinated progeny of these plantings were again planted in the nursery in August 1966. Also of interest, was a fairly rare white-flowered form of musk thistle that was found in Lancaster County associated with an infestation of normal musk thistle and scattered plants of plumeless thistle.

Rush Skeletonweed. Rush skeletonweed achenes became viable four to five days before dispersal and show no dormancy to blotter germination in Washington. The development period ranges from 11 to 15 days from flower opening. The average length of maximum hypocotyl elongation for the late flowering type is 6 to 7 mm longer than the earlier flowering type. Loss of seed viability after one year of burial in the soil ranged from 65 to 100% depending on depth of burial and whether the seed was from early flowering or late flowering type plants.

Wild Garlic. Embryonic shoots of all types of wild garlic bulbs usually elongate rapidly after dissection from the bulbs, except that they will not elongate for about one month after ripening in spring in Missouri. Microscopic studies show that embryonic shoots of wild garlic, even though in a state considered to be dormant, elongate slowly and gradually produce new leaf primordia.

Dormancy of False Hellebore and Larkspur Seeds. Dormancy was not broken in false hellebore and larkspur seeds held under snow in the forest when the seeds were not exposed to the unfrozen ground in Utah. Dormancy was shortened by one-third, however, when the seeds were subsequently transferred to optimum conditions in the laboratory. Seeds of these species when placed on the surface of unfrozen ground, but under the snow, germinated before the snow melted.

Timber Milkvetch. We have isolated the poisonous principle in timber milkvetch in pure form after separation in a counter-current distributor in Utah. Identification studies of the chemical are continuing.

Spring Parsley (Cymopterus watsonii). Physiological studies undertaken in cooperation with the Animal Disease and Parasite Division showed that the photoactive compound was present in the leaves and seeds and absent in the stems and roots. The compound is activated in the long-wave ultraviolet around 360 millimicrons. One-week-old chicks have proved to be excellent test "animals" for biological assay of this species in Utah.

One of the developments of our joint work has been the use of small chickens for bioassay. Already we have completed work dealing with the photosensitizing properties of spring parsley on chicks which would have required 200 sheep and an untold number of man-hours to collect and process enough plant material for test in large animals. In short, we have found that by using chicks for bioassay we could telescope into a single summer investigations important to both our animal and plant sciences which normally might have required several years had sheep been used. The cost of chicks versus sheep in terms of time, money, space, labor, etc. is extremely small. Many of the findings with chicks are applicable to live animals so that only final results need be confirmed with cattle and sheep.

Commercial Dehydrator Reduces Dalapon Residue. Dalapon (2,2-dichloropropionic acid) was applied to alfalfa during May 1966 at 0, 2, 5, and 10 lb./A and chopped with a field chopper two weeks later in New York. Eight hundred pound samples of each variable were passed through a commercial dehydrator-pellator. Approximately 75% of the dalapon was removed during this operation. Dalapon, as the acid, was assumed to have volatilized during the heating operation. Little degradation per se was suspected.

b. Control Studies

Weed Control in New Seedings. In Missouri, weed grasses were controlled without injury to seedling Coronilla varia L. with preplanting treatments incorporated in the soil: 3 lb/A EPTC (ethyl N,N-dipropylthiocarbamate), 1 lb/A trifluralin (alpha,alpha,alpha-trifluoro-2,6-dinitro-N,N-dipropyl-p-toluidine), 1 lb/A benefin (N-butyl-N-ethyl-alpha,alpha,alpha-trifluoro-2,6-dinitro-p-toluidine), and 3 lb/A 64-296 (mixture of 1,1-dimethyl-4,6-diisopropyl-5-indanyl ethyl ketone and 1,1-dimethyl-4,6-diisopropyl-7-indanyl ethyl ketone). Postemergence treatments with bromoxynil (dimethylarsinic acid) and 2,4-DB (4-(2,4-dichlorophenoxy)-butyric acid), severely injured this legume.

Potential interaction of EPTC and DNBP (4,6-dinitro-o-sec-butylphenol), used for weed control during establishment of alfalfa and birdsfoot trefoil was studied in the field in New York. Interactions on stand and yield of legume were considered to be insignificant. Chemical effects were due to the chemicals acting alone rather than as synergists or antagonists. Also, previous research regarding protective effects of charcoal applied in strips over rows of seeded alfalfa was verified in New York. Charcoal applied at 25, 50, and 100 lb/A protected alfalfa from adverse effects of the s-triazine herbicide G-36393.

Trifluralin, benefin and nitralin (4-(methylsulfonyl)2,6-dinitro-N,N-dipropylaniline), somewhat similar in their chemistry were similar in herbicidal activity for weed control in establishment of alfalfa and other forage legumes. Nitralin was slightly more phytotoxic at doses equimolar to trifluralin or benefin in two Maryland soils. Benefin was least phytotoxic of the three. While the standard preplanting treatment of EPTC incorporated in the soil gave excellent initial control of weed grasses, residual activity was not sufficient to provide satisfactory season-long weed control. Benefin at 1 lb/A, trifluralin or nitralin at ½ lb/A, and EPTC at 3 lb/A were adequate for selective weed grass control in alfalfa if they were incorporated in the surface two inches of soil. Control of weed competition promoted an increased hay yield in the seedling year adequate to offset the cost of control only when final alfalfa seedling density was one plant per square decimeter. More than one seedling of alfalfa per square decimeter was required to adequately use the productivity of the weed free plots.

Controlling Weeds in Humid Pastures. Fair to excellent control of bitter sneezeweed was obtained without serious reduction in stand of lespedeza with 1 and 2 lb/A of 2,4-D (2,4-dichlorophenoxyacetic acid), 1 lb/A of dicamba (2-methoxy-3,6-dichlorobenzoic acid) and 0.5 + 0.125 lb/A of 2,4-D + picloram (4-amino-3,5,6-trichloropicolinic acid) applied preemergence in Mississippi. Higher rates of picloram alone or with 2,4-D controlled the weeds but nearly eliminated lespedeza. Very similar results were obtained with sumpweed except in this test, dicamba reduced stand of lespedeza more than it had in the lespedeza trial. Postemergence applications of 0.5 and 1 lb/A of picloram or 1 + 0.25 and 2 + 0.5 lb/A of 2,4-D + picloram controlled yankeeweed or Eupatorium dog fennel 100%. Lower rates of picloram and of the mixture and 2,4-D and dicamba at 1 and 2 lb/A were much less effective.

Broomsedge in Mississippi pastures decreased in stand in established experiments where nitrogen fertilization had been combined with mowing and heavy grazing. After three to four years, broomsedge has almost disappeared. In new experiments, the first season results show a decrease in broomsedge stand, an increase in volunteer dallisgrass, an increase in production and consumption of forage, an increase in percent consumption of total vegetation or forage, and an increase in crude protein from nitrogen fertilization. All plots were mowed and grazed free choice. White clover plots were slightly better in all these respects than the checks, but inferior to nitrated plots.

In Missouri, bromoxynil applied postemergence on May 25 at 3/4 lb/A reduced yields of lanceleaf and common ragweed 93% and yields of lespedeza growing with the ragweeds increased 94%. Bromoxynil reduced yields of ragweeds to the same extent as 1 lb/A of 2,4-D amine but lespedeza treated with bromoxynil yielded 300 lb/A more than when treated with 2,4-D amine.

In a mature birdsfoot trefoil seed field, bromacil at 1 lb/A and atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine) at 1 and 2 lb/A applied in March controlled Barbarea vulgaris, Erigeron spp. and Bromus spp.

Control of Weeds in Rangelands. In Washington, minimum herbicidal treatments for control of Dalmatian toadflax included silvex (2-(2,4,5-trichlorophenoxy)propionic acid) at 3 lb/A or silvex + picloram, 2 + 1/4 lb/A, respectively. Dalmatian toadflax has the ability to invade and kill out other perennial herbaceous species by competition for moisture and possibly by a toxic principle. Life of the primary crown of Dalmatian toadflax averages about 3 years, survival beyond that time is dependent on the plants arising on lateral roots.

Bracken is killed by granular formulations of picloram and dicamba applied in the fall in northern Idaho.

Western false hellebore in Utah can be controlled by spraying the foliage of the plants when the upper leaves are fully expanded and just before flower bud initiation by 4 lb/A of: the amines or esters of 2,4-D, silvex or mecoprop (2-(2-methyl-4-chlorophenoxy)propionic acid); or a 1:1 mixture of 2,4-D and dicamba. Two treatments should be applied in successive seasons.

Low larkspur was controlled with picloram, fenac (2,3,6-trichlorophenylacetic acid), dicamba, and 2,4-D in Utah. Picloram, dicamba, and 2,4-D successfully reduced big sagebrush and silky lupine. Treatments with these three compounds also resulted in significantly increased forage production by grass species. Treatments of rangeland with the herbicides should reduce cattle losses to low larkspur and calf losses to silky lupine.

2. Brush Control

a. Physiological and Ecological Studies

Absorption and Translocation of Herbicides in Woody Plants. In most woody plant species, picloram enters the plant faster and in greater amounts than 2,4,5-T. In Texas, leaf surfaces of woody plants varied markedly in numbers and types of trichomes, stomatal arrangement, and the incidence of insect punctures. The abaxial surface of the leaf usually absorbed more than the adaxial surface when herbicide was applied to them.

Gas chromatographic and radioisotopic analyses give similar values for 2,4,5-T in mesquite tissues if identical procedures are used in processing tissues. Both methods show that most of the 2,4,5-T remains in the treated leaf and relatively little is translocated to the stem. Higher percentages of the butoxyethyl ester of 2,4,5-T is recovered from treated leaves than the ammonium salt.

Field and greenhouse investigations on velvet mesquite in Arizona have centered on the possibility of obtaining herbicidal control equivalent to that now available, but with significantly reduced spray volumes. Because of rapid evaporation of aquaeous droplets in the arid Southwest, low volatile straight oil carriers have been tried. Preliminary results suggest that such carriers will produce a comparable degree of chemical control at markedly reduced volumes. Such volume reductions could be a significant factor in lowering the cost of aerial application. Greenhouse tests have shown beneficial effects of a carrier consisting of a 1:1 mixture of dimethylsulfoxide and diesel oil. The addition of only 0.02% of a surface active agent of low hydrophile-lipophile balance (basically oil soluble) to such a carrier system resulted in a prononced increase in herbicidal translocation from the basal treated leaf to the young and old leaves above. Without the surfactant, translocation was primarily to the plant apex, and lower leaves were not visibly injured.

At Flagstaff, Arizona, translocation of ammonium thiocyanate in the evergreen shrub live oak is related to foliage development, being most rapid during optimal growth periods and slowest during period of leaf fall.

Picloram was distributed in lethal amounts throughout huisache plants grown in the greenhouse in Texas within 24 hours after treatment. Picloram persisted in plant tissue for at least 30 days with little or no apparent breakdown. Extremely low concentrations of picloram were found in aerial portions of plants from soil applications even though the plants are completely defoliated from the treatment.

Creosotebush. In a cooperative study with the Arizona Agricultural Experiment Station, the carbohydrate and nitrogen metabolism of three races of creosotebush (Larrea tridentata) were investigated. This shrub dominates about 46.5 million acres of rangeland and desert from west Texas to California. Races collected from widely divergent climatic regions of the Southwest were grown together in a controlled environment under different regimes of day/night temperature and water stress. Preliminary analyses of the foliage have demonstrated that the content of most amino acids is more dependent upon environmental treatment than upon source of collection of plant types. Amino acid concentrations were generally higher in moisture-stressed plants, particularly at the higher temperatures. Proline was an exception, being found in higher concentrations under the cooler temperatures. Significant differences in content of ether extractable materials were found among plants collected from different areas. Most of this material is resin, tar, wax, and other constituents of the cuticle. These differences could result in varying degrees of penetrability of the leaf by herbicides.

Herbicide Persistence in Soil and Water. Leaching is an important means of dissipating picloram from the upper profile of soil in studies in Texas and Puerto Rico. Photodecomposition of picloram occurs if the herbicide remains on the soil surface for long periods of time. Picloram residue

is directly related to the amount of herbicide initially applied. The persistence of picloram in the soil appeared to be influenced by rainfall, soil moisture, and soil characteristics such as physical structure and permeability.

Cucumbers were used as a bioassay in Puerto Rico for bromacil (5-bromo-3-sec-butyl-6-methyluracil), dicamba, diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea), fenac, picloram, and prometone (2-methoxy-4,6-bis(isopropylamino)-s-triazine). Concentrations as low as 0.009 ppm of these herbicides could be detected by abnormal growth characteristics of cucumbers. Visual estimation of abnormal growth could detect smaller amounts of herbicides in the soil than could be detected by differences in fresh or dry plant weight.

Small amounts of picloram (0.007-0.043 ppm) were detected in surface runoff from the El Oso chaparral plots one year after treatment. However, a larger area, Bumble Bee, had picloram residue only soon after the time of application. The potassium salt was used at El Oso, and an amine salt at Bumble Bee. Slight, temporary damage was detected on riparian vegetation as far as a mile and a half downstream from the El Oso plots.

b. Control Studies

Foliage applications of a wide variety of herbicides have shown picloram to be the most consistently effective herbicide on a pound per acre basis in providing a high level, long term defoliation of some tropical woody plants. Paraquat (1,1'-dimethyl-4,4'-bipyridinium salt) and orange (a mixture of technical esters of 2,4-D and 2,4,5-T) normally desiccate and defoliate woody plants rapidly, but the effect of paraquat is short-lived. Orange will provide effective defoliation for at least six months post treatment. A combination of paraquat + picloram will defoliate a high percentage of woody plant leaves. The fast action of paraquat has sometimes been reduced in this combination. Our results have not been consistent. Limited tests with combinations of picloram with 2,4-D and/or 2,4,5-T indicate these combinations are promising and more testing should be done with them. Herbicide combinations have increased the overall spectrum of species defoliation in some cases.

A mixture of picloram + 2,4,5-T at 1 + 1 lb/A applied aerially to several woody plant species in south Texas was as effective as picloram at 2 lb/A and more effective than 2,4,5-T at 2 lb/A. Picloram sprays at 1 and 2 lb/A applied in March through June were highly toxic to whitebrush. Sprays applied in July were less effective. Higher rates of picloram granules are needed to kill whitebrush than sprays. At Flagstaff, Arizona, Utah juniper was more sensitive than alligator and one-seed junipers to foliage applications of picloram when the plants were growing adjacent to each other in the field.

Annual April burning has controlled seedling and small plants of oak in

Oklahoma. However, fire has had very little effect on growth of medium sized and large trees. Increases in grass production have been greatest on areas where oak was killed by injector treatments with 2,4,5-T. Burning for control has increased the stand and growth of sumac, wild blackberry, horseweed, and pokeweed.

Dimethylsulfoxide added at low concentrations to picloram applied to running live oak and huisache increased the effectiveness of the treatment in Texas.

Soil sterilant studies indicated that bromacil was the most effective herbicide of ten compounds investigated at five locations in Texas.

Acorn source had a marked effect on the seedling response of shrub live oak seedling to picloram in laboratory trials. This helps explain differences of response to picloram observed in the field in Arizona.

The phytotoxicity of paraquat is only temporarily affected by low temperature. Plant tissue treated at low temperature was injured as much as tissue treated at high temperature several days after treatment. Washing woody plants soon after treatment significantly reduced the effectiveness of paraquat.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Weed Investigations - Grazing Lands

1. Poisonous and Other Herbaceous Weeds

a. Control Studies

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SHADE-, ORNAMENTAL- AND WINDBREAK-TREE BREEDING, DISEASES AND CULTURE
Crops Research Division

Problem. Research is needed to find more effective and less costly disease-control methods for shade tree diseases. Because the use of DDT has been prohibited in some cities and is in disrepute elsewhere, a new control for Dutch elm disease is urgently required. The loss of elm trees has increased the demand for new trees better suited to modern highway, city, and home designs. In the Great Plains, establishment of trees for farm windbreaks is difficult. Studies of ways to ensure survival of newly planted trees are fundamental to economic windbreak establishment. Substantial factual information is required on the effect of windbreaks on improvement of living conditions for men, on farm livestock, and crop production in order to guide design planning and choice of windbreak species.

USDA AND COOPERATIVE PROGRAM

The urgent need for more effective methods to combat Dutch elm disease dictated that the disease receive priority in our research on shade tree diseases. The Dutch elm disease problem receives special attention at Beltsville, Md., and at Delaware, Ohio. At Tifton, Ga., mimosa wilt is the only problem under study. Work on live oak canker and sweet gum blight was discontinued during 1966. At Mandan, N.D., research continued on the effects of windbreaks on crop yields. At Cheyenne, Wyo., study of the culture and propagation of trees for farmstead windbreaks is in progress. At Tucson, Ariz., research on the cause and control of lethal rot of saguaro is conducted. The research at Delaware, Ohio, is cooperative with the Ohio Agricultural Experiment Station, and at Tifton, Ga., with the Georgia Agricultural Experiment Station.

The Federal scientific effort assigned to this area totals 9.2 scientist man-years divided as follows: breeding 0.5, diseases 4.7, culture 4.0.

PROGRAM OF STATE EXPERIMENT STATIONS

The research effort of the State experiment stations in this area totals 18.0 scientist man-years. 1/

1/ These scientist man-years are also reported in the Forest Service Progress Report in connection with Timber Management research.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Breeding

1. Elm. Four shoot cuttings of the tetraploid Ulmus pumila were rooted under mist in 1966. These rooted cuttings are insurance against accidental loss of the original tetraploid. Also, rooted cuttings having the histogenic composition 4-4-4 were produced from a plant having a 2-4-2 histogenic structure. The conversion to 4-4-4 was accomplished by taking shoots from root cuttings and then rooting the shoots under mist. Shoots from root cuttings arise from the second histogenic layer and their chromosome number is the same as cells in that layer. No natural tetraploids were found among several hundred shoots from untreated root cuttings of U. pumila and U. parvifolia.

2. Mimosa. In Georgia, selections of wilt resistant mimosa were increased in anticipation of eventual release.

B. Diseases

1. Elm. Dutch elm disease reduced the velocity of organic solute translocation in 30-year-old American elms. A decline of 80 percent in carbon 14 transport 2 weeks after inoculation with Ceratocystis ulmi was recorded. A low-cost plastic chamber was devised and constructed for use in measurements of photosynthesis in healthy and in diseased elms. A technique was developed for labeling spores of Ceratocystis ulmi with radiocarbon. Evidence was obtained that 3-month-old American elm seedlings inhibit spread of the fungus in the inoculated seedling and eventually possibly destroy it. The fungus could not be isolated 16 weeks after inoculation into trees 3 months old at the time of inoculation. The cause of the failure of the fungus to survive was not determined. Spore load of inoculum was not important in final severity of disease in inoculated young trees. Twelve weeks after inoculation of 8-year-old elms severity of disease was equal in trees inoculated with spore suspensions containing 10^2 or 10^6 spores per ml. A Fusarium root rot of elm was described.

2. Mimosa. Mimosa trees dying from the wilt disease frequently produce a heavy seed crop. The wilt organism, Fusarium oxysporum f. perniciosum, was culture from surface sterilized seed taken from diseased trees. Shipment of infected seed could, therefore, be a means of spreading the disease to noninfested areas. Infected seed could also be a source of disease in seedlings grown for experiments in sterilized soil.

C. Culture

1. Materials, production and management of farmstead windbreaks. Series of one- or multiple-row windbreaks planted at intervals of 20 or 40 rods across fields to reduce soil blowing, and sand-blasting of crops, and to trap snow for increasing soil water, have no cumulative effect in reducing

wind velocity or in trapping snow. When identical species of like age and spacing distance in the row are used, snowdrifts on the leeward sides of belts and wind velocities between belts are identical. North-south belts form deep, narrow drifts and east-west belts form drifts 3 to 4 times wider and about half the depth of the north-south ones. About the time of the first spring thaw, about March 15 of each year, snowdrifts have a density of about 43 percent. The drifts form a potential water tank averaging 3.5 to 4 feet deep, up to 40 feet wide, and of the length of the windbreak. Sufficient water is present to spread 2-3 inches over an area 15 to 25 times the width of the drift or most of the area between 40-rod belts. Topography frequently prevents this spread and confines the water to the drift area. Sheet and gully erosion result. Some progress is being made to accomplish a wider distribution of snow and resultant water by (1) increasing the spacing of trees in the row, and (2) by removing lower branches from existing trees.

2. Crop-plant response to field windbreaks. Wind barriers erected across fields yielded further data on their influence in reducing wind velocity and increasing soil water and crop yields. These wind barriers increased over-winter buildup of soil moisture from trapped snow out to 14 times the barrier height in the top 6 feet of soil on the leeward side. The increase on the windward side did not extend beyond 6 heights and did not penetrate deeper than 4 feet. Wheat yields in the first 20 and 25 barrier heights were 12 and 8.5 bushels, respectively, greater on the leeward side. Deep snowdrifts formed on either side of barriers caused an unfavorable reverse wind action on their leeward sides. This action clears the land of all snow for some distance beyond the drift. It can be corrected only by providing windbreak structures with more porosity in their bottom parts which, in turn, will produce wider and more shallow snowdrifts.

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